On the retrieval of the effective temperature of the ozone profile from ground-based spectropolarimetric measurements

Peter Krieden and Joseph Michalsky
Boulder, Colorado, USA

Fundamental uncertainty of ozone measurements

Ozone column abundance from Dobson and Brewer spectrometers is obtained from extraction measurements at a few discrete wavelengths. In the Brewer four wavelengths are used to obtain a classical linear expression to derive column ozone:

\[ D_\lambda /X_{SC} = (I_{R}(\lambda) /I_{D}(\lambda)) = C_T \sin(\theta) \]

where \( D/\lambda \) is a linear combination of transmittance at different wavelengths, \( X_{SC} \) is the ozone cross-section, \( C_T \) is the effective ozone and \( \sin(\theta) \) is the ozone. The transmittance are solved in such a way to cancel the effect of the unknown aerosol optical depth. This necessitates the use of a shadow bouncing method where the ozone cross-section happens to have the strongest temperature dependence. It is impossible to design ozone profile retrievals that are temperature independent using only a few wavelengths (Thomason and Herman 1985). The Dobson and Brewer models at least five times to account for the influence of temperature on the retrieved ozone profile. It is not sufficiently accurate to use in retrievals. A better definition of the temperature of the ozone profile is needed that approximates the \( T_C \) best in a given spectral region. This temperature we call ozone profile cross-section temperature \( T_{CS} \).


Calibration and performance of RSS

The RSS is calibrated using Langley regressions. The Langley regression analysis is performed on the 349 µm wavelength (2300 Å) in the UV for measurements at night. This is used to evaluate the RSS algorithm. To examine the consistencies between wavelengths the scans from the mask are used in the regressions for all the other wavelengths. However, due to poor signal-to-noise ratios at the shortest wavelengths, some scans for larger air masses are omitted in the regressions. The calibration constant \( K_{cal} \) is obtained by solving the linear regression equation:

\[ D_\lambda /X_{SC} = m_{cal} + n_{cal} = \sum_{\lambda} (I_{R}(\lambda) /I_{D}(\lambda)) - 1 \]

where \( I_{D}(\lambda) \) is Earth transmittance. It is essential to use a ozone column estimate \( D_\lambda \) to obtain correct values of \( T_{CS} \).

The temperature of the cross-section \( T_{CS} \) is the one that from data on temperature. The Dobson and Brewer method uses Dobson and Brewer cross-sections at 227K and 229K respectively. Dobson and Brewer results cannot accurately reflect ozone column changes because the measured temperatures do not always agree with the actual ozone profile temperature. The small difference of 2K between the two methods due to differences between Dobson and Brewer wavelengths is used to obtain the temperature of the cross-sections \( T_{CS} \).

The Dobson and Brewer wavelengths are assigned sequentially for optimal ozone profile retrieval. The Dobson and Brewer wavelengths are assigned sequentially for optimal ozone profile retrieval. Due to the presence of strong temperature dependence, Dobson and Brewer results cannot accurately reflect ozone column changes because the measured temperatures do not always agree with the actual ozone profile temperature. The small difference of 2K between the two methods due to differences between Dobson and Brewer wavelengths is used to obtain the temperature of the cross-sections.

Recently, direct and diffuse transmittances (Total and TCS) obtained with the RSS and derived using \( \sigma(z) \) from Dobson regressions were compared with transmittances calculated with the TUV model for various cases of AOD, SSA, SA, g and SZA for data when the RSS was deployed at the ARM site in Oklahoma in May 2003 (Michalsky and Krieden 2000).

Empirical ozone cross-sections

Consistency of ozone retrievals is maintained by using a set of empirical ozone cross-sections. We have chosen ozone cross-sections: Baseline (baseline BP), Paur and Box (Paur and Box 1993). We have compared results from various cross-sections: Baseline BP, Dobson and Brewer (Dobson and Brewer 1993). The acronyms BP, DBM and GMFM are adopted from Liu et al. (2007). The cross-sections have been used in ozone column and ozone profile retrievals. For example, Dobson and Brewer cross-sections at 227K and 229K respectively. Dobson and Brewer results cannot accurately reflect ozone column changes because the measured temperatures do not always agree with the actual ozone profile temperature. The small difference of 2K between the two methods due to differences between Dobson and Brewer wavelengths is used to obtain the temperature of the cross-sections.

The Dobson and Brewer wavelengths are assigned sequentially for optimal ozone profile retrieval. Due to the presence of strong temperature dependence, Dobson and Brewer results cannot accurately reflect ozone column changes because the measured temperatures do not always agree with the actual ozone profile temperature. The small difference of 2K between the two methods due to differences between Dobson and Brewer wavelengths is used to obtain the temperature of the cross-sections.

Empirical ozone cross-sections:

Comparison with 3 with 0.15 absorption gain for best ozone profile retrievals. The ozone profile cross-section retrieving the ozone profile cross-sections was compared with transmittances calculated with the TUV model for various cases of AOD, SSA, SA, g and SZA for data when the RSS was deployed at the ARM site in Oklahoma in May 2003 (Michalsky and Krieden 2000).

Ozone temperature retrievals

Ozone column for 3211 (x ≤ 0.010D5 scan (10 scans for a day for altitudes < 4) was retrieved using BP cross-sections with the method described in section 4.2. The Dobson and Brewer cross-sections at 227K and 229K were compared with transmittances calculated with the TUV model for various cases of AOD, SSA, SA, g and SZA for data when the RSS was deployed at the ARM site in Oklahoma in May 2003 (Michalsky and Krieden 2000).

The empirical ozone cross-sections are parameterized using the linear squares algorithm. The Dobson and Brewer cross-sections at 227K and 229K were compared with transmittances calculated with the TUV model for various cases of AOD, SSA, SA, g and SZA for data when the RSS was deployed at the ARM site in Oklahoma in May 2003 (Michalsky and Krieden 2000).

Ozone profile cross-section

As long as radiation is quasi-monochromatic the solar Lambert-Beer law holds for the reflectively-errant path through the ozone profile \( \sigma(z) \) (baseline BP), Dobson and Brewer cross-sections. \( \sigma(z) \) is the one profile cross-section independent of ozone cross-section. To define ozone profile cross-section \( s(z) \), vertical temperature \( T(z) \) and cross-section retrievals were done at 25K intervals along the observation path. Then \( s(z) \) and \( n(z) \) can be derived from formulas that can be found in (Thomason et al. 1985).

Here we derive a method that is not dependent on \( n(z) \), but where the temperature dependence is negligible. The method that can be found in (Thomason et al. 1985).